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# Author's Accepted Manuscript

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A population-based study of premorbid scholastic achievement among patients with psychiatric disorders.

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## Abstract

Population-based studies of premorbid cognitive functioning in schizophrenia have found verbal deficits and low IQ scores. It remains unclear, however, whether premorbid deficits are specific to schizophrenia, compared with other psychiatric disorders. Moreover, studies using school-based measures are few and their results

inconsistent. This study assesses the eighth-grade (ages 13-14;  $n=11,418$ ) scholastic performance of adults with psychiatric disorders ( $n=194, 1.7\%$ , particularly with schizophrenia ( $n=86, 0.8\%$ ), comparing the results with those of their normative peers. The researchers examined report cards of eighth-graders at state secular schools in Jerusalem over a ten-year period (1978-1988), applying ANOVA and logistic regression models to evaluate associations between school performance and subsequent psychiatric hospitalization. The findings indicated that participants hospitalized with varied psychiatric disorders had lower grades in mathematics, gym, handcraft and academic core subjects, with significantly lower overall scores. Amended logistic regression models indicate that reduced performance (in mathematics, gym, handcraft and overall scores) was correlated with an increasing likelihood of hospitalization for the psychiatric disorders group and the subgroup with schizophrenia-related ailments. These results imply that eighth-grade school performance in core subjects is poorer among persons later hospitalized with psychiatric disorders than that of their classmates.

## **1. Introduction**

Premorbid cognitive impairment is one of the most consistent findings in schizophrenia (Aylward et al., 1984; Cannon et al., 2000; Dickson et al., 2014; Woodberry et al., 2008). In the British 1946 birth cohort, educational test scores at ages 8, 11 and 15 years were impaired among persons with schizophrenia (Jones et al., 1994). A meta-analysis of population-based studies found a deficit of approximately half a standard deviation in children and adolescents who develop

schizophrenia as adults (Khandaker et al., 2011). Another study showed that by age 16, individuals who developed schizophrenia subsequently displayed significant deficits in IQ and motor function, but not in general academic or mathematics achievements (Dickson et al., 2012).

An important issue that remains unresolved is whether premorbid cognitive impairments are specific to schizophrenia, or are similarly present across a wide range of psychiatric disorders. The main aim of the current study was to examine whether poorer school performance as early as the 8<sup>th</sup> grade (ages 13-14) is related to later hospitalization for a broad range of psychiatric disorders. We also examined a smaller subgroup with schizophrenia-related disorders to determine whether the trends were similar to those for all psychiatric disorders. Although poorer school performance is not identical to cognitive impairment, the two are correlated and the former constitutes a more accessible measure in population studies (Cannon et al., 1999, Fuller et al., 2002, MacCabe et al., 2008, Wu et al., 2014).

Poor premorbid functioning has not been considered central to the development or diagnosis of psychiatric disorders, such as mood disorders, or personality disorders (American Psychiatric Association, 2000). Nevertheless, recent studies suggest that premorbid maladjustment may not be unique to schizophrenia. Instead, schizophrenia and other psychiatric disorders may all be preceded by some degree of academic impairment (Tarbox et al., 2012; Weiser et al., 2004). A longitudinal assessment of scholastic tests showed that eleventh-grade language and reading scores were below average among teenagers who developed schizophrenia (Fuller et al., 2002). Tarbox and colleagues (2012) found premorbid academic performance impairment to be associated with schizophrenia and with schizoaffective and mood disorders. It should be noted, however, that retrospective assessment of academic performance raises a

question of recall bias and may be based on an overall estimate rather than a measure of cognitive ability per se (Tarbox et al., 2012). A recent study in Western Australia shows that twelve-year-olds whose mothers suffered severe mental illness were more likely to perform below acceptable standards on academic achievement tests. Moreover, Poor spelling was associated with later development of psychosis (Lin et al., 2016). Vreeker and colleagues (2015) discovered that educational performance was higher among bipolar patients and lower among those with schizophrenia.

A previous study (Ullman et al., 2012) focused primarily on premorbid functioning in schizophrenia, addressing all aspects of scholastic activity. The present study broadens this perspective and examines the presence of premorbid scholastic achievement across an extensive wide range of psychiatric disorders.

Previous studies led us to posit that students who subsequently develop psychiatric disorders – and schizophrenia in particular – will reveal inferior premorbid scholastic performance in core subjects.

## 2. Method

Teacher-rated eighth-grade scholastic achievements were compared between persons hospitalized for psychiatric disorders and a control group within 17-27 years of completing eighth grade (ages 13-14).

### 2.1 Registries

#### 2.1.1 Israel National Psychiatric Hospitalization Case Registry

This registry comprises a comprehensive list of all cases of psychiatric institutionalization in Israel, including regularly updated ICD-10 diagnoses by board-certified psychiatrists on the patients' release from the hospital. Israeli law requires all day hospitals and other in-patient facilities to report psychiatric intake and release accordingly. Ministry of Health officials monitor registry entries for compliance with regulations governing reporting and data consistency, ensuring that the registry provides comprehensive and accurate information. The law further stipulates that psychiatric care is freely available to all bona fide residents of Israel (Levav and Grinshpoon, 2004). As such, it enabled identification of all former and present cases of hospitalization in the research group. We selected the last diagnosis before release or the intake diagnoses for persons institutionalized at the time the registry listings were merged (see *Data Linkage*, below) (Levine et al., 2011). Studies of psychiatric disorder diagnoses obtained from the registry and evaluated in a similar manner have displayed satisfactory sensitivity and specificity when measured against research diagnoses (Weiser et al., 2005), as well as long-term reliability (Rabinowitz et al., 1994). The cohort comprising persons with psychiatric disorders included patients with schizophrenia-related illnesses (ICD codes F20-F29 – n=86), affective disorders (F31-F341 – n=29), anxiety (F409-F44 – n=22), personality disorders (F60-F632 – n=42) and other psychiatric problems (F911 – n=5; F70 – n=2; Z03 – n=1; Z032 –

n=1; F500 – n=5 and F502 – n=1). The schizophrenia spectrum covered all types of schizophrenia, including schizotypal and delusional disorders.

### *2.1.2 Jerusalem School Grade Archive: Eighth-grade scores (ages 13–14)*

From 1978 to 1988, the Jerusalem Municipality routinely collected eighth-grade records – the only elementary school data retained – of students at all local state schools (secular, religious and ultra-orthodox) (Ullman et al., 2012). This study addresses schools in the city of Jerusalem alone, excluding others in the Greater Jerusalem metropolitan area. Education in Israel is compulsory and free for children aged six and up, who attend neighborhood schools near their homes. This study concentrates exclusively on eighth-graders (ages 13-14) at state secular schools (n=11418), that served the majority of Jerusalem's elementary school students at the time. With attention to previous research (Ullman et al., 2012), we omitted religious and ultra-orthodox institutions from the study, thereby precluding possible effects induced by curriculum differences. Studies of Israeli school systems display varied patterns of curriculum implementation among them. The state Jewish educational system in Israel comprises three semi-independent subsystems, according to intensity of religious affiliation: Secular, religious and ultra-orthodox. These differences respond to sectorial cultural needs, especially insofar as curriculum planning is concerned. In practice, the national religious sector enjoys a high degree of administrative and instructional autonomy, largely controlling its schools' curriculum content and emphases, with a considerable measure of choice left to each such institution (Gonen and Alon, 2015; Resh and Benavot, 2005; Taub et al., 1996).



To prevent possible confounding of differential curricula and ensure focus on academic achievement only, we limited this study to the secular school system, that then served the largest population sector. Special education schools were excluded from the annual data as well (Ullman et al., 2012).

Subject grades ranged from 40 to 100 (excellent). Conduct, orderliness and motivation were also graded on a scale of 1 (poor) to 6 (superior), divided into pairs labeled low (1-2), medium (3-4) and high (5-6). Student files provided the following key information: (1) Grades in nine core subjects – native language (Hebrew), mathematics, English, gym, science, history, handcraft, chronicles, Bible); (2) behavior ratings (i.e., conduct, orderliness and motivation); (3) student ID number. (4) tracks in mathematics and English (as a second language), taken into account by handicapping raw scores for lower tracks, that used a simpler syllabus taught at a slower pace: If there were two tracks in either subject, the lower group's scores were reduced by 40 points; three tracks – 25 (English) or 30 (mathematics) points, calculated following consultation with eighth-grade mathematics and English teachers and Ministry of Education supervisors. Overall grades were determined according to mean grades (unadjusted and adjusted) in all core subjects. In this case, the relevant data comprises teacher-assigned grades for the entire year's performance, including scores achieved in the June final examinations. The research team entered the data into a new file sorted according to eighth grade completion year, school identification number, student's sex and subject and behavior variables. Dual data entry was mandated to ensure precision.

## 2.2 Data linkage

Lists updated to the end of 2005 were merged in January 2006, using personal ID numbers (assigned to each Israeli at birth or naturalization) as variables. The Ministry

of Health unit responsible for management of the National Psychiatric Hospitalization Case Registry linked that file (correct as of the end of October 2005) with the school file and returned it following removal of identifying material. Linkage was approved by the IRB of Bar-Ilan University. Linkage resulted revealed 194 cases (1.7%) of state secular school students diagnosed with psychiatric disorders, including 86 with schizophrenia (0.8% overall) and 108 psychiatric disorders not including schizophrenia (0.9% overall). Data linkage was 99% successful.

### *2.3 Analysis*

Chi-square tests of independence were conducted to determine whether sex and teacher rating for classroom behavior are related to psychiatric hospitalization.

The data consisted of teacher-assigned grades in major eighth-grade subjects: Native language, mathematics, English, gym, science, history, handcraft, chronicles and Bible. As all academic subjects were distributed normally, one-way ANOVA models were analyzed to compare the performance of students subsequently admitted to psychiatric hospitalization with that of control group members and to conduct a similar comparison among those specifically diagnosed with schizophrenia. Separate logistic regression models were constructed for each subject, controlled for sex and behavior scores.

## **3. Results**

The research group comprised 11,418 persons, of whom 49% were male. Cross-referencing with the National Psychiatric Hospitalization Registry revealed that 194 had been hospitalized for psychiatric disorder at least once since eighth grade, 86 of them for schizophrenia.

According to Chi-square tests of independence, the only statistically significant relationship between psychiatric disorder and behavior was the correlation between teacher-rated classroom behavior ( $p=.045$ ; see Table 1) and psychiatric disorders not including schizophrenia.

Table 1: Psychiatric disorders, schizophrenia and psychiatric disorders not including schizophrenia vs. control group according to sex and teacher-rated classroom behavior

		N	Prevalence rates (%)			
			Total (n=11418)	Control (N=11224)	Psychiatric disorders (N=194)	Schizophrenia disorders (N=86)
<b>Sex<sup>1</sup></b>						
Male	5,589	49.0	48.9	54.6	55.8	53.7
Female	5,807	51.0	51.1	45.4	44.2	46.3
<b>Teacher-rated classroom behavior</b>						
<b>Conduct</b>						
High	10,128	88.7	88.8	85.1	89.5	81.5 <sup>2</sup>
Medium	959	8.4	8.3	11.3	7.0	14.8
Low	331	2.9	2.9	3.6	3.5	3.7
<b>Orderliness</b>						
High	9,906	86.8	86.8	85.1	88.4	82.4
Medium	1144	10.0	10.0	10.3	7.0	13.0
Low	368	3.2	3.2	4.6	4.7	4.6
<b>Motivation</b>						
High	9027	79.1	79.1	75.3	76.7	74.1
Medium	1698	14.9	14.8	16.5	14.0	18.5
Low	693	6.1	6.0	8.2	9.3	7.4

Notes:

<sup>1</sup>; N=22 missing cases from control group

<sup>2</sup>According to Chi-square tests of independence, the only statistically significant relationship between psychiatric disorder and behavior was the correlation between teacher-rated classroom behavior ( $p=0.045$ ) and psychiatric disorders not including schizophrenia.

Figure 1 displays eighth-grade school grades of all cohort members. Those who were subsequently hospitalized with a psychiatric disorder had lower grades in all core subjects (native language, mathematics, English, gym, science, history, handcraft, chronicles, Bible). Statistically significant differences were evident regarding mathematics ( $p=0.012$ ), gym ( $p=0.033$ ), handcraft ( $p<0.001$ ) and total mean scores ( $p=0.008$ ).

**Figure 1:** Comparison of psychiatric disorder cohort (last admission) and control group eighth-grade scores at state schools in Israel

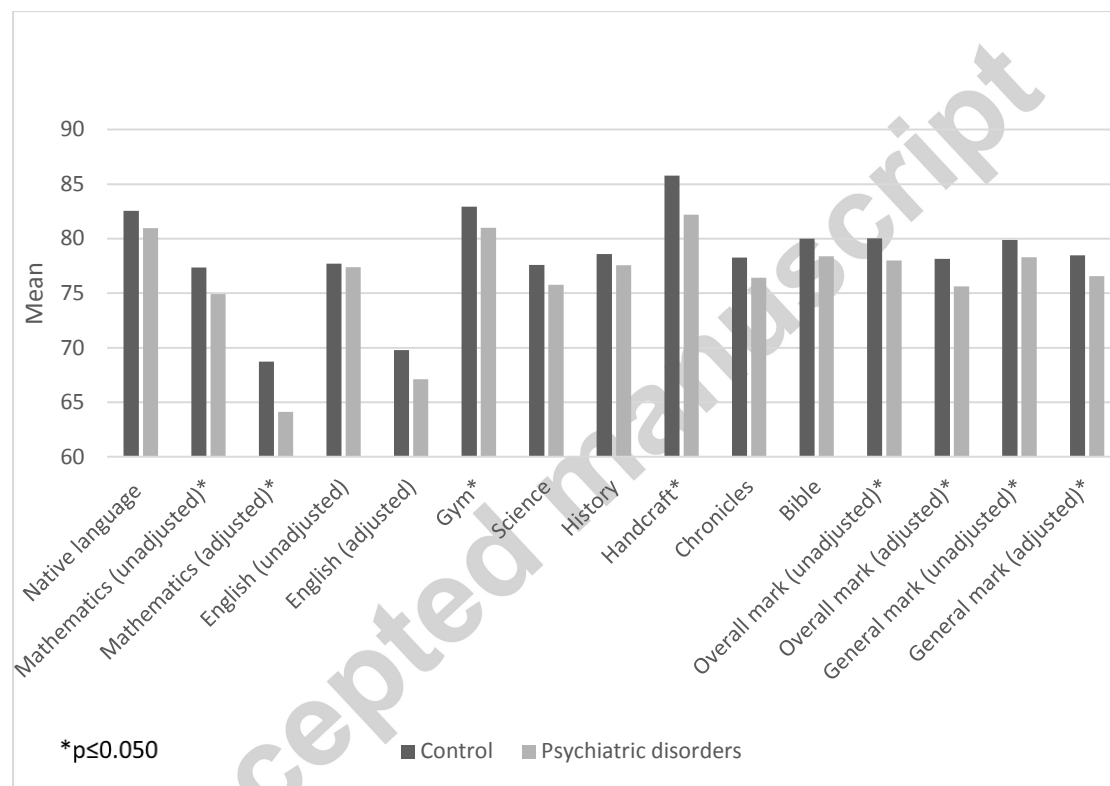


Figure 1: Differences in eighth-grade school grades between persons later hospitalized for psychiatric disorders and those in the control group. Subject performance was derived from grades in native language, mathematics, English, gym, science, history, handcraft, chronicles and overall score (mean scores of all academic core subjects).

Table 2 shows the results of logistic regression models controlled for sex and behavior (conduct, orderliness and motivation), revealing that mathematics (unadjusted and adjusted), gym, handcraft and overall marks (unadjusted and adjusted) had significant impact for prediction of hospitalization with psychiatric

disorders ( $p = 0.045, 0.022, 0.046, 0.002, 0.028$  and  $0.016$ , respectively). The higher the grade, the less likely the student will be hospitalized for psychiatric disorders, especially with regard to handcraft scores (lowest odds ratio=0.982).

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Table 2: Predictors of hospitalization with psychiatric disorders, compared with control group data (logistic regressions)

Eighth-Grade Scores <sup>1</sup>	Control N	Psychiatric disorders N	B	S.E. <sup>2</sup>	Wald $\chi^2(1)$	p	O.R. <sup>3</sup>	95% C.I. <sup>4</sup>
Native language	10,746	185	-0.007	0.006	1.275	0.259	0.993	0.981 - 1.005
Mathematics (unadjusted)	11,013	191	-0.011	0.005	5.004	<b>0.045</b>	0.989	0.979 - 1.000
Mathematics (adjusted)	11,013	191	-0.007	0.003	5.286	<b>0.022</b>	0.993	0.987 - 0.999
English (unadjusted)	10,913	179	0.000	0.005	0.001	0.981	1.000	0.990 - 1.010
English (adjusted)	10,913	179	-0.004	0.003	1.575	0.209	0.996	0.989 - 1.002
Gym	10,758	185	-0.012	0.006	3.991	<b>0.046</b>	0.988	0.976 - 1.000
Science	10,866	189	-0.006	0.005	1.146	0.264	0.994	0.985 - 1.004
History	10,901	184	-0.003	0.006	0.374	0.541	0.997	0.986 - 1.008
Handcraft	8,736	163	-0.018	0.006	9.371	<b>0.002</b>	0.982	0.970 - 0.993
Chronicles	10,963	186	-0.007	0.005	1.881	0.170	0.993	0.983 - 1.003
Bible	11,051	190	-0.006	0.006	0.992	0.319	0.994	0.983 - 1.005
Overall mark(unadjusted)	11,002	187	-0.017	0.008	4.814	<b>0.028</b>	0.983	0.968 - 0.998
Overall mark (adjusted)	11,002	187	-0.017	0.007	5.819	<b>0.016</b>	0.984	0.972 - 0.997

*p* values less than 0.05 are indicated in bold.

<sup>1</sup>Each row represents a separate logistic regression model. Models were controlled for sex and teacher-rated classroom behavior (conduct, orderliness and motivation). All scores were continuous variables.

<sup>2</sup>S.E.: Standard Error

<sup>3</sup>O.R.: odds ratio – Values indicate that as scores rise, the likelihood of hospitalization for psychiatric disorders decreases.

<sup>4</sup>95% C.I. of O.R.: 95% confidence interval of odds ratio.

Figure 2 displays eighth-grade school grades of cohort members with schizophrenia and their normative peers. Children later hospitalized and diagnosed with schizophrenia had lower grades in all academic school core subjects (native language, mathematics, English, gym, science, handcraft, chronicles, Bible), with statistically significant differences for grades in gym ( $p=0.021$ ) and handcraft ( $p=0.021$ ).



**Figure 2:** Comparison of schizophrenia (last admission) and control group members' eighth-grade scores at state schools in Israel

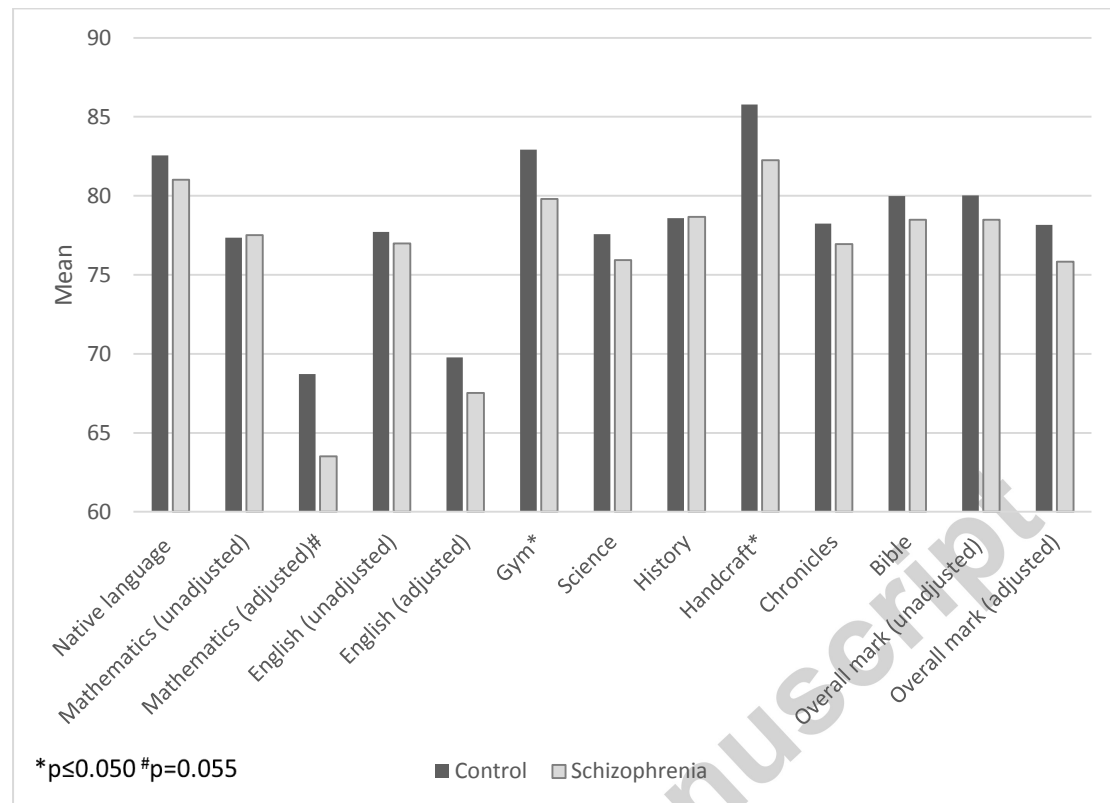


Figure 2: Differences in eighth-grade school grades between persons later hospitalized for schizophrenia and those in the control group. Subject performance was derived from grades in native language, mathematics, English, gym, science, history, handcraft, chronicles and overall score (mean scores of all academic core subjects).

Table 3 shows the results of logistic regression models controlled for sex and behavior (conduct, orderliness and motivation), revealing that mathematics (adjusted), gym and handcraft had significant impact for prediction of hospitalization with schizophrenia ( $p = 0.045, 0.022, 0.046, 0.002, 0.028$  and  $0.016$ , respectively). The higher the grade, the less likely the student will be hospitalized for schizophrenia, especially with regard to handcraft scores (lowest O.R.: 0.980; 0.982).

Table 3: Predictors of hospitalization with schizophrenia, compared with control group data (logistic regressions)

Eighth-Grade Scores <sup>1</sup>	Control	Schizophrenia			Wald		O.R.	95%
	N	N	B	S.E. <sup>2</sup>	$\chi^2(1)$	p	<sup>3</sup>	C.I. <sup>4</sup>
Native language	10,74 6	83	- 0.00 7	0.00 9	0.55 1	0.45 8	0.993	0.975 - 1.012
Mathematics (unadjusted)	11,01 3	85	0.00 1	0.00 8	0.03 3	0.85 5	1.001	0.986 - 1.017
Mathematics (adjusted)	11,01 3	85	- 0.00 9	0.00 4	4.13 2	<b>0.04</b> <b>2</b>	0.991	0.982 - 1.000
English (unadjusted)	10,91 3	83	- 0.00 1	0.00 8	0.01 1	0.91 7	0.999	0.984 - 1.014
English (adjusted)	10,91 3	83	- 0.00 3	0.00 5	0.33 7	0.56 2	0.997	0.998 - 1.007
Gym	10,75 8	83	- 0.02 0	0.00 9	5.38 2	<b>0.02</b> <b>0</b>	0.980	0.963 - 0.997
Science	10,86 6	86	- 0.00 6	0.00 7	0.56 7	0.45 2	0.994	0.980 - 1.009
History	10,90 1	83	0.00 2	0.00 8	0.06 8	0.79 5	1.002	0.986 - 1.019
Handcraft	8,736	71	- 0.01 8	0.00 9	3.98 9	<b>0.04</b> <b>6</b>	0.982	0.965 - 1.000
Chronicles	10,96 3	85	- 0.00 5	0.00 8	0.39 1	0.53 2	0.995	0.980 - 1.010
Bible	11,05 1	86	- 0.00 6	0.00 8	0.50 0	0.47 9	0.994	0.978 - 1.011
Overall mark (unadjusted)	11,00 2	85	- 0.01 2	0.01 1	1.08 3	0.29 8	0.988	0.966 - 1.011
Overall mark (adjusted)	11,00 2	85	- 0.01 4	0.01 0	2.19 8	0.13 8	0.986	0.967 - 1.005

*p* values less than 0.05 are indicated in bold.

<sup>1</sup>Each row represents a separate logistic regression model. Models were controlled for sex and teacher-rated classroom behavior (conduct, orderliness and motivation). All scores were continuous variables.

<sup>2</sup>S.E.: Standard Error

<sup>3</sup>O.R.: odds ratio – Values indicate that as scores rise, the likelihood of hospitalization for schizophrenia decreases.

<sup>4</sup>95% C.I. of O.R.: 95% confidence interval of odds ratio.

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Figure 3 presents eighth grade scholastic achievement school grades of cohort members hospitalized for psychiatric disorders not including schizophrenia and their normative peers. Children later hospitalized for such psychiatric disorders had lower grades in all academic school core subjects (native language, mathematics, English, gym, science, history, handcraft, chronicles, Bible), with statistically significant differences for grades in gym ( $p=0.021$ ) and handcraft ( $p=0.021$ ).

**Figure 3:** Comparison of patients with psychiatric disorders (not including schizophrenia) and control group members eighth-grade scores at state schools in Israel

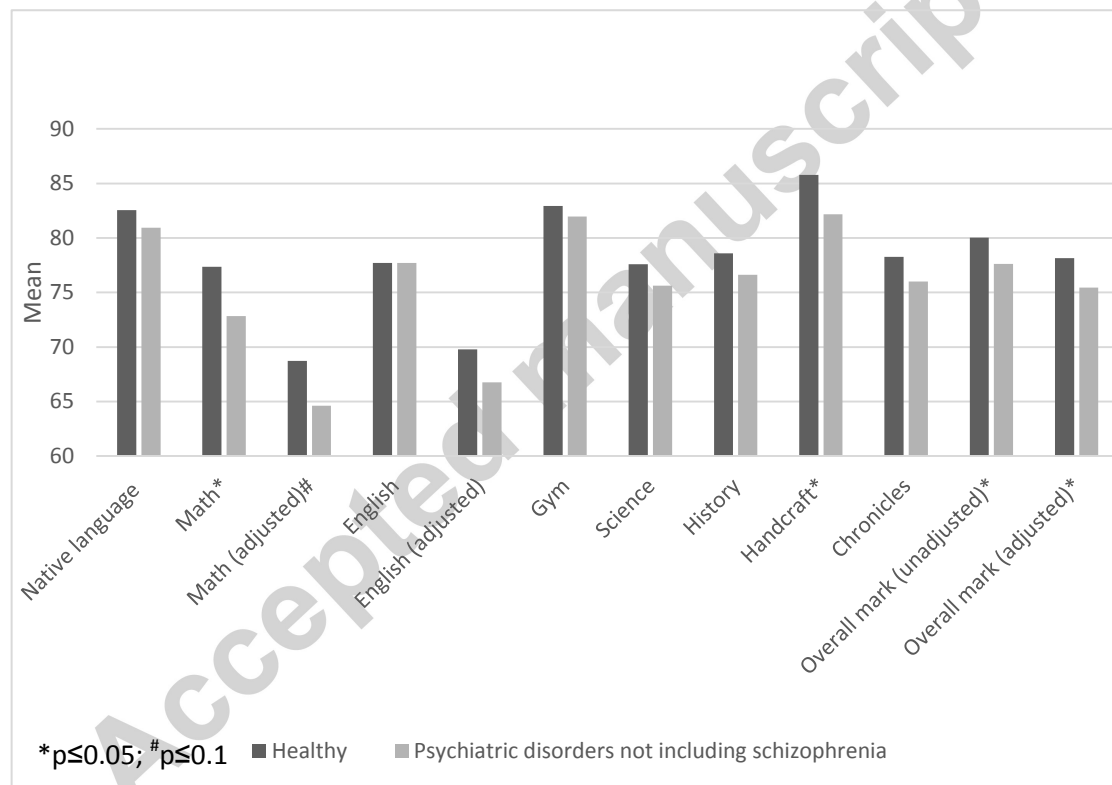


Table 4 shows the results of logistic regression models controlled for sex and behavior (conduct, orderliness and motivation), revealing that mathematics (unadjusted), handcraft and overall mark had significant impact for prediction of hospitalization with psychiatric disorders other than schizophrenia ( $p = 0.045$ ,  $0.019$  and  $0.041$ , respectively). The higher the grade, the less likely the student will be

hospitalized for such disorders, especially with regard to mathematics and handcraft scores (lowest O.R.: 0.980; 0.982).

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Table 4: Predictors of hospitalization with psychiatric disorders (not including schizophrenia), compared with control group data (logistic regressions)

Eighth-Grade Scores <sup>1</sup>	Control N	Psychiatric disorders not including schizophrenia <sup>a</sup> N	B	S.E. <sup>2</sup>	Wald $\chi^2(1)$	p	O.R. <sup>3</sup>	95% C.I. <sup>4</sup>
Native language	10,746	102	-0.007	0.008	0.737	0.391	0.993	0.976 - 1.009
Mathematics (unadjusted)	11,013	106	-0.020	0.007	8.233	<b>0.004</b>	0.980	0.966 - 0.994
Mathematics (adjusted)	11,013	106	-0.005	0.004	1.660	0.198	0.995	0.987 - 1.003
English (unadjusted)	10,913	96	0.000	0.007	0.004	0.949	1.000	0.986 - 1.015
English (adjusted)	10,913	96	-0.005	0.005	1.402	0.236	0.995	0.986 - 1.004
Gym	10,758	102	-0.005	0.008	0.376	0.540	0.995	0.979 - 1.011
Science	10,866	103	-0.006	0.007	0.678	0.410	0.994	0.981 - 1.008
History	10,901	101	-0.008	0.007	1.132	0.287	0.992	0.978 - 1.007
Handcraft	8,736	92	-0.018	0.008	5.471	<b>0.019</b>	0.982	0.967 - 0.997
Chronicles	10,963	101	-0.009	0.007	1.678	0.195	0.991	0.977 - 1.005
Bible	11,051	104	-0.005	0.008	0.511	0.475	0.995	0.980 - 1.009
Overall mark (unadjusted)	11,002	102	-0.021	0.010	4.167	<b>0.041</b>	0.979	0.959 - 0.999
Overall	11,00	102	-0.00	0.00	3.75	0.053	0.983	0.966

mark	2	0.01	9	2	#	-
(adjusted)		7				1.000

*p* values less than 0.05 are indicated in bold; #*p*<0.01

<sup>1</sup>Each row represents a separate logistic regression model. Models were controlled for sex and teacher-rated classroom behavior (conduct, orderliness and motivation). All scores were continuous variables.

<sup>2</sup>S.E.: Standard Error

<sup>3</sup>O.R.: odds ratio – Values indicate that as scores rise, the likelihood of hospitalization for psychiatric disorders not including schizophrenia decreases.

<sup>4</sup>95% C.I. of O.R.: 95% confidence interval of odds ratio.

#### 4. Discussion

This population-based study demonstrates that poor school performance at age 13-14 is associated with psychiatric disorders and with schizophrenia. Children subsequently hospitalized with psychiatric disorders displayed poorer performance in native language, mathematics (adjusted and unadjusted), English (adjusted), gym, science, history, handcraft, chronicles, Bible and overall marks, with particularly significant differences in mathematics, gym, handcraft and overall marks. A Comparison between a subgroup of schizophrenia and their control group peers revealed similar trends. These findings uniquely enhance previous research, indicating that persons hospitalized with psychiatric disorders later in life, and specifically schizophrenia, display poor achievement in mathematics and other core subjects at the end of eighth grade (MacCabe et al., 2008; Cannon et al., 1999).

To date, Prospective studies assessing premorbid school performance in childhood and early adolescence have been inconclusive (MacCabe et al., 2008). A registry study of 16-year-olds in Sweden (MacCabe et al., 2008) found premorbid academic deficits in native language and mathematics among people who developed schizophrenia or other psychoses. Isohanni (1998) followed the northern Finland birth cohort of 11,017 individuals until the age of 28, using the Finnish Hospital Discharge

Register. low school grades at age 16 predicted only non-psychotic disorders and had no association with psychosis. In another Finnish study, using a nested case control design, Cannon et al. (1999) studied prospective data from children born in Helsinki during the 1950s. School grades and teachers' ratings at ages 7-11 were identified for cases of schizophrenia and compared with controls. Cases performed significantly worse than controls only on the nonacademic factor (sports and handcraft) and were less likely to progress to high school. A recent Israeli study (Ullman et al., 2012) found that children subsequently hospitalized with schizophrenia had lower nonacademic performance and teacher ratings on behavior than controls. Surprisingly, one study reported that excellent school performance at age 16 indicated an increased risk of schizophrenia among 58 boys from a birth cohort of 11,017 (Isohanni et al., 1999). The role of mathematics, verbal and motor academic functioning in early adolescence as risk factors for psychiatric disorders was thus unclear, emphasizing the importance of new population-based school performance studies.

Overall, previous studies emphasize premorbid verbal deficits as characteristic of persons at risk of psychiatric disorders (Gur et al., 2014). A military prospective study in Israel found that poorer verbal reasoning was associated with increased risk of schizophrenia (Reichenberg et al., 2006). Dickson (2014) observed deficits in verbal comprehension and verbal working memory in children at-risk for psychosis. Although certain studies of premorbid cognitive functioning in psychiatric disorders do mention verbal deficits (Ang and Tan, 2004; Dickson, 2012), none has discovered any specific association to date between standardized achievement in mathematics and various psychiatric disorders (Wu et al., 2014). The present study noted an association between poor school performance in mathematics at age 13 with various psychiatric disorders presenting later in life.



In Israel and elsewhere, standardized measures of mathematical and verbal achievements are a routine component of annual academic assessment and consequently serve as a potential tool for examining cognitive vulnerability in the premorbid period (Wu et al., 2014). While other researchers use standardized IQ tests (Jones et al., 1994; Khandaker et al., 2011; Zammit et al., 2004), the present study preferred scholastic achievement data that provide a more overt manifestation of intelligence and approximate real life situations.

Previous studies have already confirmed the existence of premorbid cognitive deficits in schizophrenia (Dickson et al., 2014; Khandaker et al., 2011; Reichenberg et al., 2010). This study broadens the scope of research by describing the premorbid performance of persons with various psychiatric disorders. Thus, schizophrenia and other psychiatric disorders may all be preceded by academic functional decline (Tarbox et al., 2012; Wu et al., 2014).

The current results provide evidence that cognitive impairment is present years before hospitalization, long before the symptoms were sufficiently intense to warrant formal diagnosis. Individuals who were hospitalized with varied psychiatric disorders and a subgroup of schizophrenia are cognitively impaired in contrast to their peers on main subjects learned in school at early adolescence.

#### *4.1 Limitations*

The use of school grades and teacher ratings is not standardized the way IQ tests are and therefore it is not designed to detect abnormalities in general and specifically abnormalities of psychiatric disorders. However, grades and rating at school are routinely given as part of academic assessments in most of the countries and can

therefore serve as a potential available tool for examining functioning vulnerability in the premorbid period (Ang and Tan 2004; Dickson et al., 2012).

In our study, as in the general population, admissions for psychiatric disorders were 1.7% and for a sub group of schizophrenia were 0.8%. There for, the small number of cases did not enable us to create multivariable models of all the grades together.

The present findings indicate that adolescents aged 13-14 with poor achievements in mathematics, gym or handcraft exhibit significantly greater vulnerability to psychiatric disorder and schizophrenia diagnosis later in life.

Additional research is required to determine separate premorbid signs for each psychiatric disorder separately and to plan a longitudinal study of decline in functional skills over time.

In conclusion, this study confirms previous research, uniquely indicating that low premorbid achievements in core eighth-grade subjects correlate with increased likelihood of hospitalization for psychiatric disorders and specifically schizophrenia.

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### **Authors' Contributions**

Zerem Ullman drafted the manuscript and planned the research in collaboration with Reichenberg and Hornik-Lurie. Hornik-Lurie planned and carried out the analysis.

Reichenberg also provided critical manuscript feedback. All authors were involved in all aspects of the study and all read and approved the final manuscript.

### **Conflict of Interests**

The authors hereby declare that they have no conflict of interests.

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## Highlights



- We compared scholastic achievements at ages 13-14 between persons hospitalized during adulthood for psychiatric disorders and particularly for schizophrenia versus their peers.
- This population-based study demonstrated that poor school performance at age 13-14 correlates with psychiatric disorders and schizophrenia.
- Persons later hospitalized with psychiatric disorder displayed poorer performance in all academic school core subjects. Significantly, in mathematics, gym, handicraft and overall mark (mean scores of academic core subjects).
- Our study uniquely indicates that low premorbid achievements are associated with increased risk for admissions of psychiatric disorders and specifically schizophrenia.